Reflections on Ad Hoc Cooperative Teams

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ABSTRACT

We present in this paper our first reflections on the application of cooperative technologies into ad hoc networks domain. Our work aims at defining models concerned with both cooperation and ad hoc mobility. To do that, first we discuss some problems tied to the ad hoc deployment of a cooperation application already defined for wired networks. This discussion is motivated by the base on the ad hoc network specificities. Second, we give some guidelines to study the performance optimization of ad hoc protocols using cooperation technology.

1 INTRODUCTION

The current evolution of cooperative technologies aims to support many application types, in particular those dedicated for cooperative teams. This evolution is emerging, but still needs effective concepts and mechanisms to enter a real development stage. A virtual team is a group of partners distributed in time, in space, over organizations and gathered around a common project. These partners can thus carry out common objectives thanks to the deployment of their complementary competencies and knowledges. Indeed, the cooperation allows partners to get benefit from knowledge and competence of each other.

Current cooperative technologies are designed for wired networks. Nevertheless, it seems important to continue to offer this kind of cooperation in on-the-fly formed networks named ad hoc networks.

An ad hoc [2, 4] network is a dynamic reconfigurable multi hop wireless network in which mobile hosts communicate over a shared channel. It is characterized by the absence of a wired backbone that manages the interconnection between its mobile nodes. Applications such as disaster recovery and automated batter fields are typical examples of Ad Hoc networks. One desirable qualitative property of an ad hoc protocol is that it should adapt to the high potential network topology changing.

In many instances, tools and frameworks for cooperative teams have been developed without real support for spontaneous applications deployed in ad hoc networks. Indeed, ad hoc networks deployment lack facilities to support cooperation. In fact, we think that ad hoc mobility will physically facilitate cooperation of a team, but this will need a deep study of ad hoc network characteristic influence on the behavior of cooperation architectures.

Moreover, ad hoc networks did not get benefit of results in cscw domain [6, **?**]. Indeed, We think that it is interesting to optimize deployment of an ad hoc network using information about cooperative applications. A successful deployment of an ad hoc network needs obviously the spontaneous cooperation of all nodes forming the network. Thus, it seems important to get benefit from the cooperation applications to deploy a cooperative ad hoc network: in this case, an example of cooperation is concerned with maintaining the physical connection of the ad hoc network. Our objective in this paper is to give some guidelines to study the feasibility of cooperation in ad hoc networks and for ad hoc networks.

The remainder of this paper is organized as follows: the section 2 presents an example of a cooperative team application. The section 3 presents examples of ad hoc scenarios that motivate the necessity of renewing the study of cooperative policies. The section 4 presents our reflections for a scalable cooperative architecture aiming deploying scalable services. Finally, perspectives are presented in the section 5.

2 Cooperative team example

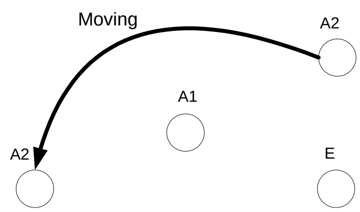

Figure 1: A cooperative team example: $A1$ and $A2$ are two architects and E is an engineer

We can propose a scenario in which a group of partners working on an architectural design project were obliged to spontaneously do a field work. Thus, they deploy an ad hoc network in the terrain that is the subject of the architectural design. Assume that in this given architectural design project there are two architects and an engineer (see figure 1). The architects are the responsible for the production of the final plan of the building and all of the related documents. Thus, the architects modify together the plan in parallel and in a synchronized way. The engineer follows the architect cooperative work. However, the engineer can be in charge of some parts of this plan or of some technical details in case of necessity.

In the next section, we will use this example to explain the open issues we are interested in.

3 Ad Hoc networks for cooperation

Existing implementations of collaboration systems, with their centralized server architectures and expectations of relatively benign environments, are not well suited to the demands of mobile users in ad hoc networks. The spontaneous deployment nature of ad hoc networks lead us to renew our reflection for an entirely distributed cooperative system: the server no longer makes sense. In addition, this system has to take into account the frequent mobility of its members. We present in the following the main characteristics of ad hoc networks that have to be a subject of interest in the case of cooperative work establishment.

3.1 Frequent mobility

Unlike fixed networks, partners of a cooperative group are more free to move. This will not guarantee that some partners, having important roles in the cooperation, are continuously reachable by other partners. For this reason, we think that policies already defined for wired network have to be adapted to keep similar performances in a mobile network. For example, a member disconnection in a wired network can be interpreted by his/her absence. In mobile networks, particularly ad hoc ones, in most cases, the member disconnection can be interpreted by his/her movement or the radio propagation change. In fact, when a group deploys an ad hoc network, all participating members aim to stay inside the network until their common objective is reached. Thus, policies managing partners should take into account the temporarily disconnection of certain members.

To clarify our discussion above, we give an example. Suppose that $A1$ and $A2$ (see figure 1) cooperate synchronously.

When $A2$ disappears, $A1$ can invite E to participate in the development of the building plan. This scenario will occur if the work is urgent and important, the engineer has enough competence to participate in the cooperation and $A2$ is still absent after a timeout has expired. This constitutes an adapted cooperation policy for ad hoc networks.

A second adapted policy can be interesting: after $A2$ became absent, E proposes to $A1$ a cooperation.

3.2 Resource optimization

Current cooperative technologies are based on the fact that the current internet guarantees some packet delivery reliability. This guarantee is not yet offered by ad hoc mobile networks. Thus, attention should be attributed to policy establishment to minimize bandwidth use. We give in the following an example.

Suppose that $A1$ and $A2$ (see figure 1) use a synchronized cooperation. E can participate in the plan development. This means, each one is all the time aware about all operations done by the other. This kind of cooperation is bandwidth expensive since a high number of message exchanges is necessary to permit this synchronization. This is not only not desirable in ad hoc mobile networks but also can be impossible to be deployed. In fact, these architects share the medium with other persons and the provided bandwidth is limited. For this reason, we propose to use another approach of synchronized cooperation based on synchronization points. One solution is that each architect can update its view related to the other architect operations after a specific period δ has expired. Another solution is that each architect notifies the other about the operations he/she did after a minimum number of new executed operations n_{op}. These solutions surely minimize the overhead induced in the network by the cooperation. Even though, an evaluation of this overhead is necessary to study the performances of this kind of cooperation in ad hoc networks. We remind that bandwidth is limited and shared with other members. In addition, this evaluation will make it possible to adjust the value of δ or n_{op}. For this reason, we think that cooperative policies can be applied in a real network if network simulation or analytical study are curried to prove the feasibility of applying cooperative policies in this kind of environments.

3.3 Hidden node problem

In this section, we give an example of a well known problem tied to the multiple access protocol in ad hoc environments: the hidden node problem [3, 5]. For example in the figure 1, we say that $A2$ is hidden to E and vice versa, because both of them don't detect each other and thus can access to the medium. This is a problem because both of them can send in the same time to $A1$. A collision can thus occur.

In this example, cooperative policies have to be specified in the case, a local ad hoc network is the underlying communication network.

In the case of wired networks, each node can reach each other since the underlying infrastructure is fixed. Unlikely, in ad hoc networks, the radio links change frequently, dependably on user mobility and environment propagation. Thus, each node can be unreachable at any moment, just because he/she has changed position or received radio signal becomes weak due to propagation change. In the figure 1, $A2$ can move, but still in range of communication with $A1$. Thus, it can continue to cooperate with $A1$. Though, E is no longer in range of communication of $A2$. This means, E can not cooperate with $A1$ and $A2$ unless $A1$ informs him/her that $A2$ is still in cooperation. To resolve the situation in which $A2$ moves, we can use the adapted policies we proposed above:

1. E proposes to $A1$ a cooperation.

2. $A1$ invites E for cooperation.

The first solution is not well adapted. Indeed, after E proposition, $A1$ will certainly refuse because he/she is still in cooperation with $A2$.

Nevertheless, the second solution is better because messages are induced only in necessity following the reactive principle in ad hoc networks.

4 SCALABLE COOPERATION: COOPERATION FOR AD HOC NETWORKS

One of the emerging research subjects concerned with ad hoc networks is: how can a group continuously guarantee the connection between all the partners? Since by nature, this kind of networks is not organized and no infrastructure is used, a mechanism has to be introduced to overcome service missing such us a connection with a member who physically can not be reached by his group.

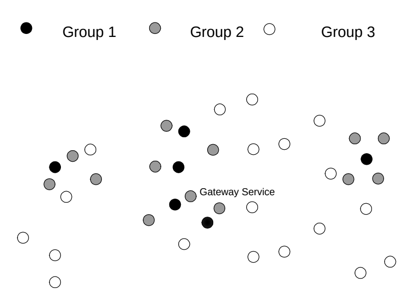

Figure 2: Cooperation in scalable ad hoc networks

We think that cooperation between different ad hoc networks deployed within the same terrain is important. This importance is justified by the fact the spontaneous deployment of each network implies a need of services that can be accessed in the neighbor networks. Obviously, cooperation between all the networks can be ensured in an ad hoc manner but not in isolated manner: standardized cooperation policies have to be established to make possible a network using the services of an other network in a coordinated way.

The most important service, a member of an ad hoc network wants to continuously keep, is connection with the other members of his/her group. Thus, a cooperative system can make possible a disconnected member to access to a gateway service of another network. Accessing to another service is possible if all ad hoc networks have already established the specific access policies [1] in their cooperative architecture. For example (see figure 2), a network $n2$ deployed by the group 2, possesses an ad hoc node which its role is similar to the role of a base station, i.e. this node can relay packets. A member of the network $n1$ deployed by the group 1 can use the base station node if this last one is not too charged and if it pays for the service. Unlikely, all members of the network $n2$ can use this service. We can imagine other policies which will strongly depend on the strategy of each ad hoc group. This kind of scalable cooperation has a common objective for all these ad hoc groups or networks: the use of services is based on policies already established by these groups.

5 Perspectives

We have presented in this paper some guidelines for ad hoc cooperation teams.

First, we have presented the most important points that differ a wired network from an ad hoc one. On the base of certain differences, we give examples where new policies have to be established or already designed policies have to be adapted. This means that renewing the cooperation models is very important.

Second, we propose a new application of the cooperation in the context of ad hoc networks. We present our reflections on the possibility of cooperation in scalable ad hoc networks. Work should be done to study more in deep our proposals and to prove that ad hoc networks and cooperation can serve each other.

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